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(54) **DEVICE AND METHOD FOR DRYING WORK PIECES**

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F26B 15/18 (2006.01)

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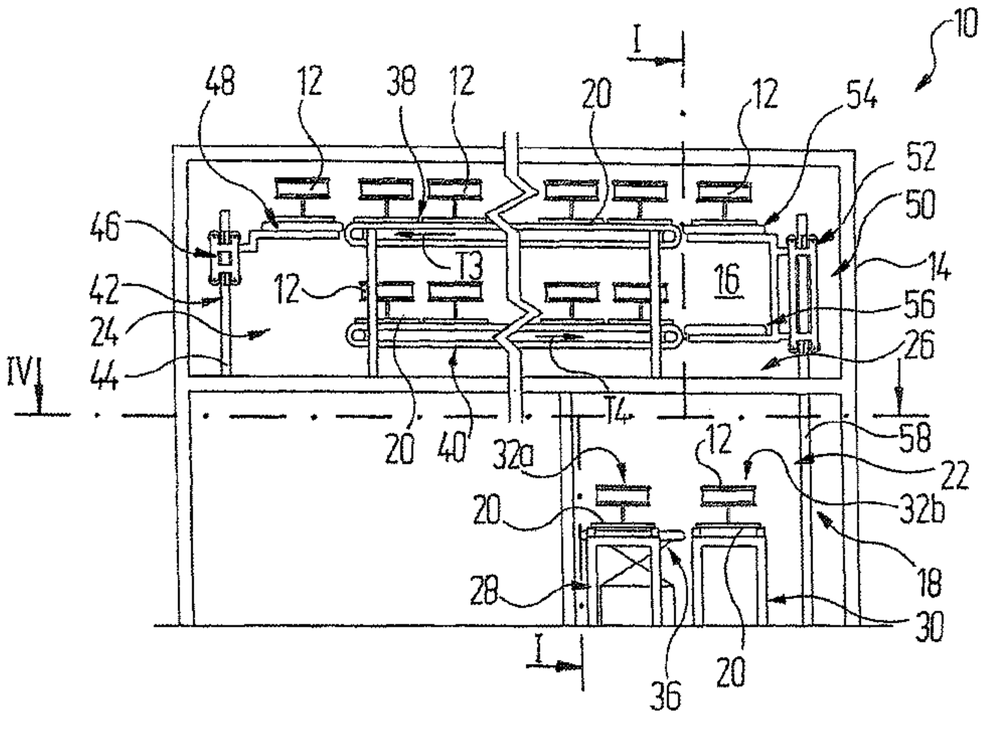
(57) **ABSTRACT**

A device for drying work pieces, in particular vehicle wheels, having a dryer housing which borders a dryer chamber and has at least one access to the dryer chamber. Work piece carriers loaded with work pieces can be conveyed through the dryer chamber by a conveyance system. There is a transfer device which transfers work pieces to be dried to a work piece carrier located in the dryer chamber, and removes dried work pieces by a work piece carrier located in the dryer chamber. The work piece carriers can be conveyed in circulation through the dryer chamber without leaving same. A method for drying work pieces, wherein the work piece carriers are correspondingly conveyed through the dryer chamber without leaving same, wherein work pieces to be dried are transferred to a work piece carrier located in the dryer chamber and dried work pieces are removed by a work piece carrier located in the dryer chamber.

17 Claims, 5 Drawing Sheets



(58) **Field of Classification Search**
USPC 34/186, 194, 203, 223, 229, 236, 267, 34/284, 304, 328, 380, 418; 510/189; 53/122; 432/82
See application file for complete search history.

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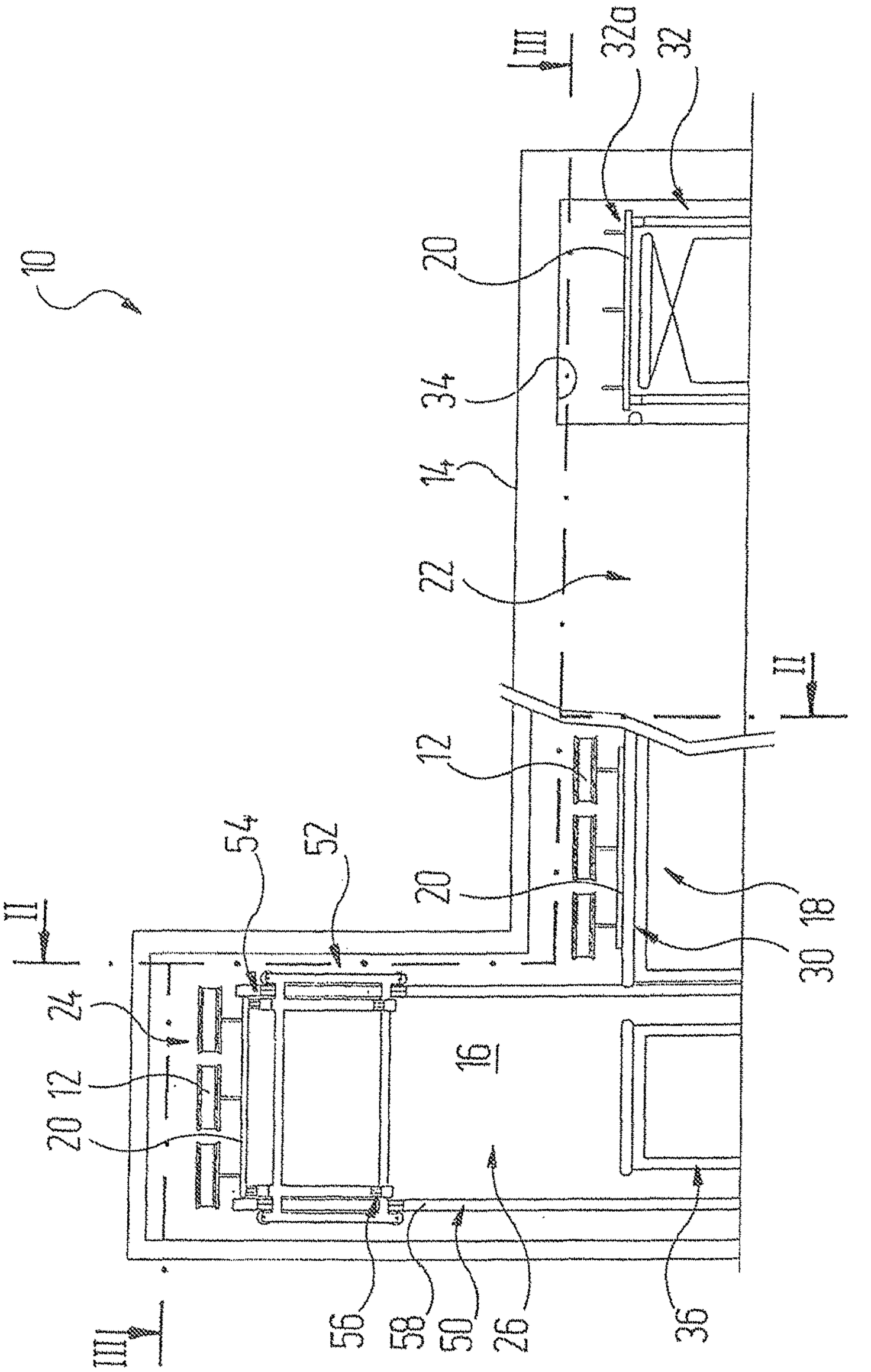
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34
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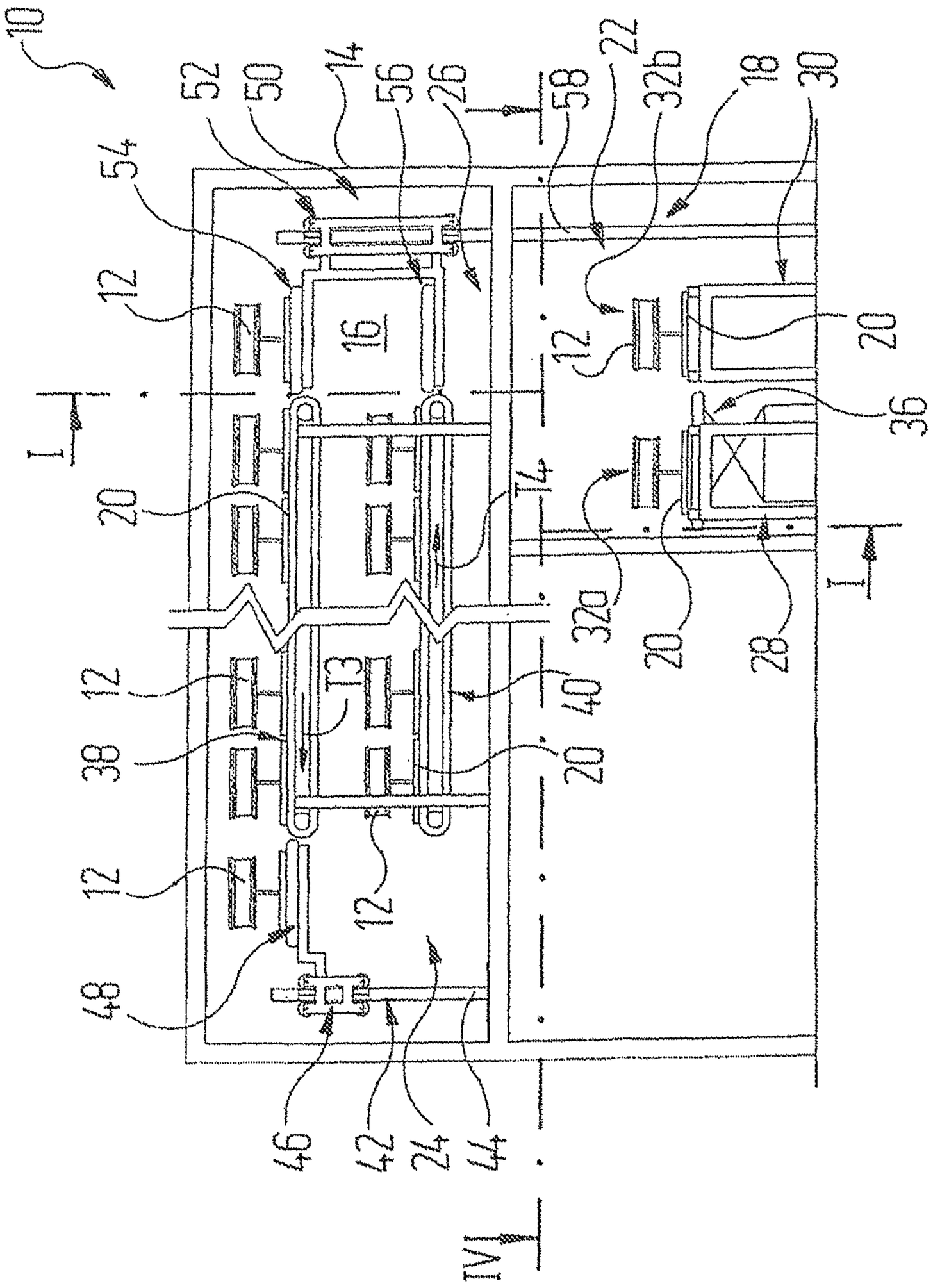
III

Fig. 1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32a
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IVI

Fig. 2

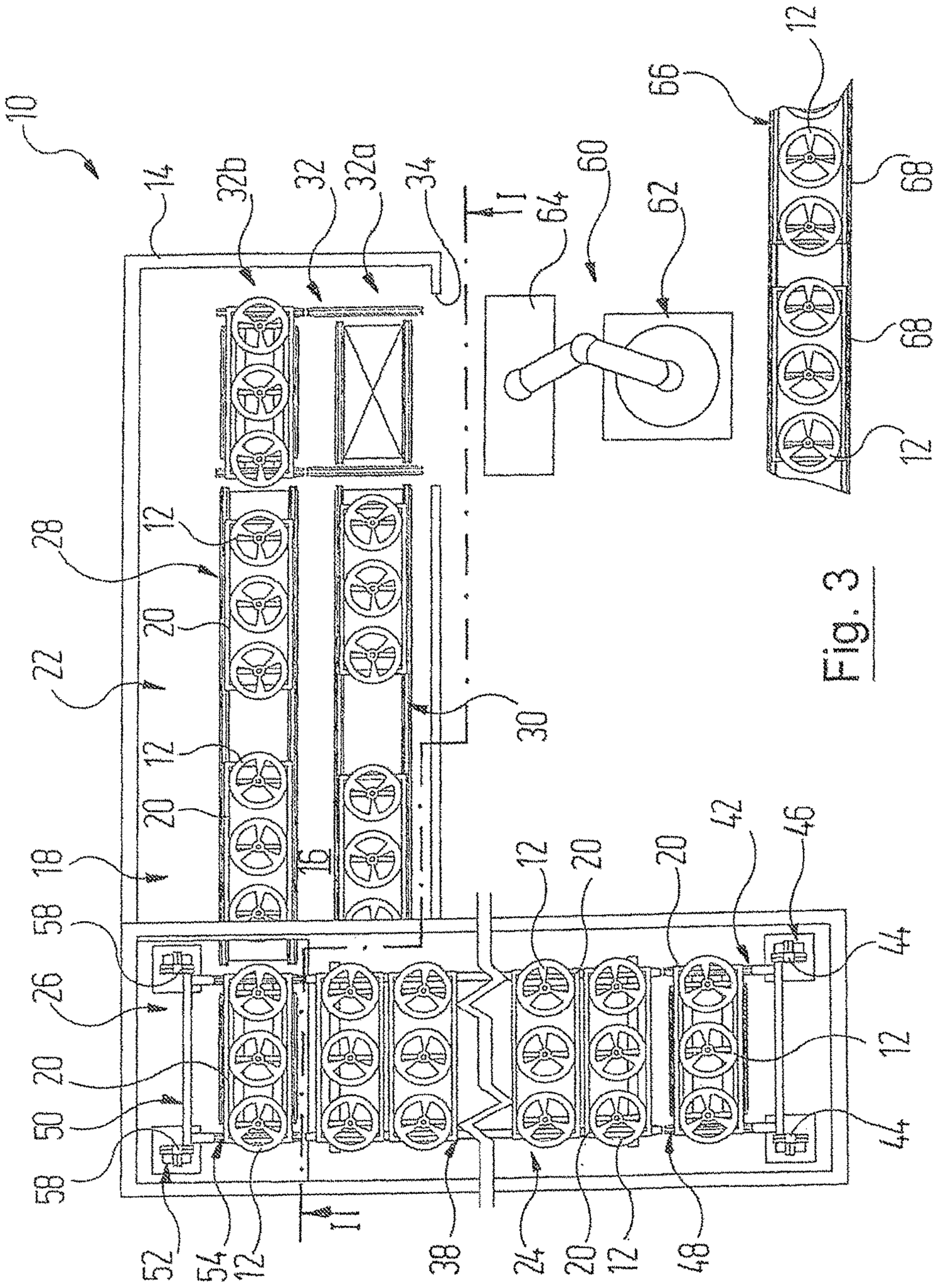
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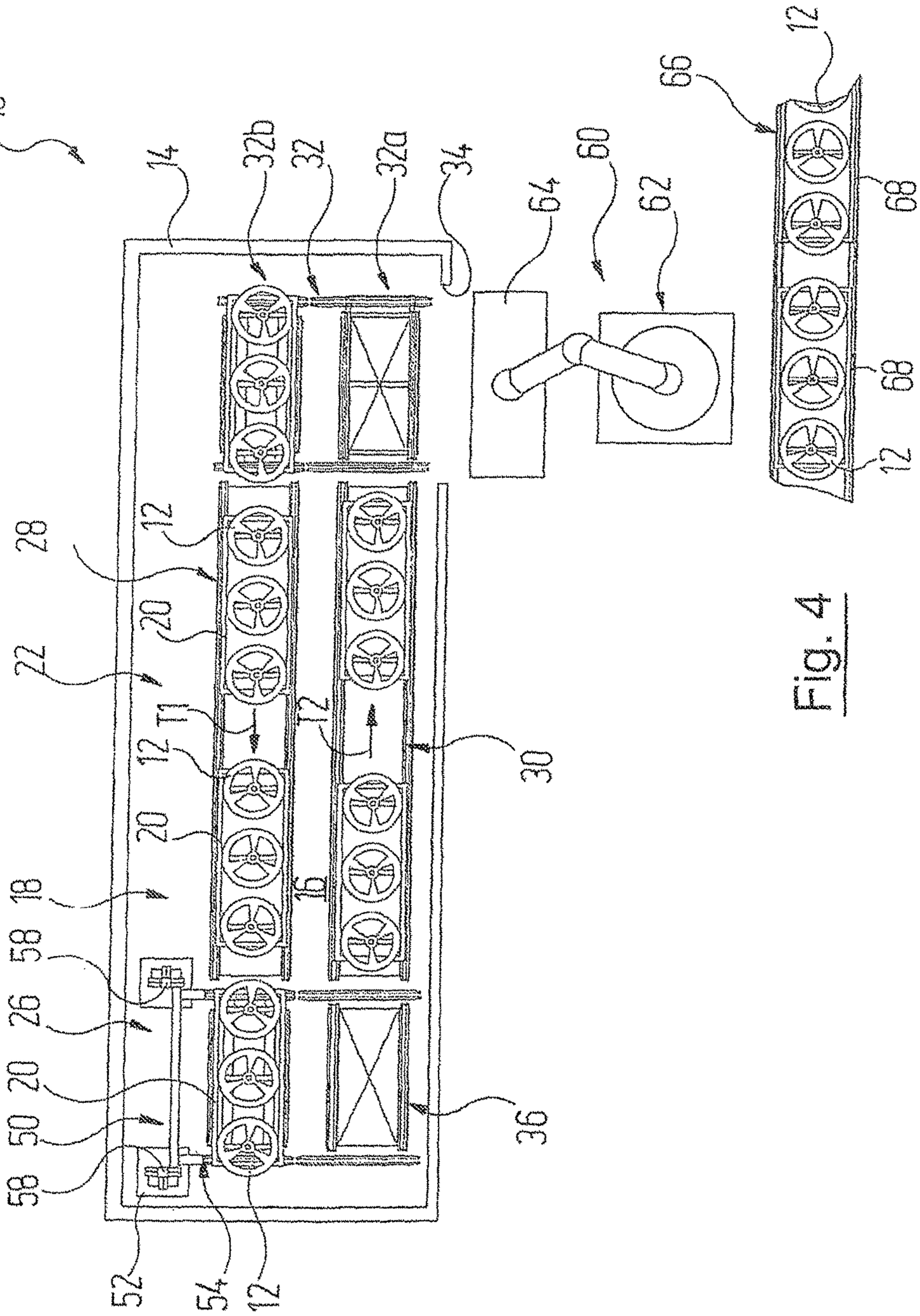
Fig. 3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T1
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30
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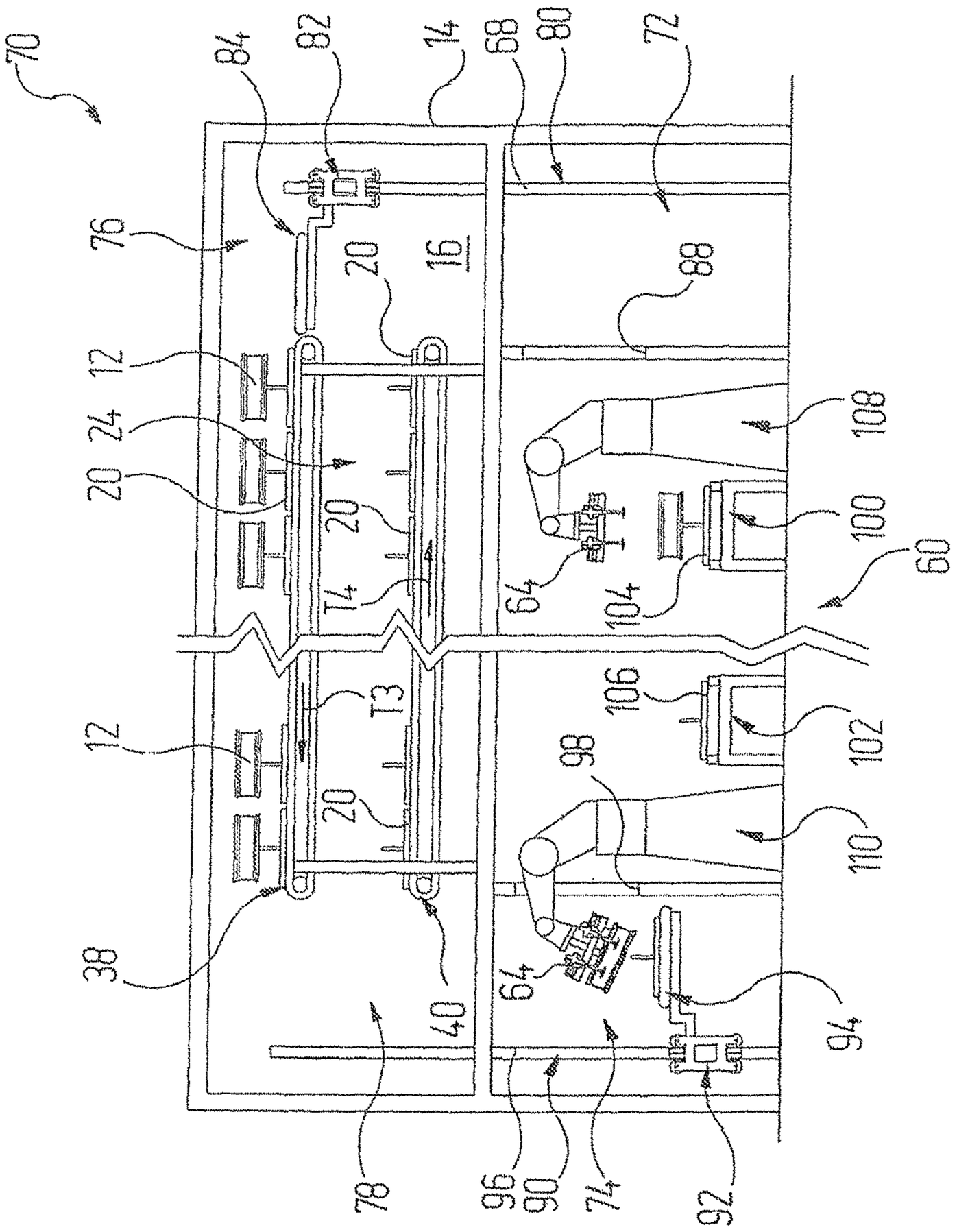
Fig. 4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20
T4
64
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60
12
T3
106
102
20
98
110
38
64
40
94
78
96
90
74
92

Fig. 5

DEVICE AND METHOD FOR DRYING WORK PIECES

RELATED APPLICATIONS

This application claims the filing benefit of International Patent Application No. PCT/EP2012/001844, filed on Apr. 28, 2012, which claims the filing benefit of German Patent Application No. 10 2011 101 277.3, filed May 12, 2011, the contents of both of which are incorporated herein by reference.

FIELD OF THE INVENTION

The invention relates to a device for drying workpieces, in particular vehicle wheels, comprising:

a) a dryer housing which borders a dryer chamber and has at least one access to the dryer chamber;

b) a conveying system by means of which workpiece-carriers loaded with workpieces can be conveyed through the dryer chamber.

The invention also relates to a method for drying workpieces, in particular vehicle wheels, in which workpiece-carriers loaded with workpieces are conveyed through a dryer chamber.

BACKGROUND OF THE INVENTION

Devices and methods of this kind which are known from the market are used, for example, in order to dry freshly painted workpieces, or even workpieces whose surface has been treated in some other way, in a drying oven. This should also be understood to include, in the present case, the stoning of powder coatings onto workpieces.

In the present case, vehicle wheels are mentioned as an example of the workpieces to be dried. However, the workpieces to be dried may also be other assemblies and components which may also be produced from non-metallic materials, in particular from plastic. If the components in question are fairly small parts, these may be accommodated in a carrying basket or the like which may be fastened to the workpiece-carrier.

In the case of drying ovens and methods which are known from the market for the purpose of drying vehicle wheels, it is usual for a number of vehicle wheels to arrive from a preceding treatment on a workpiece-carrier and then to be conveyed, also on the latter, through the dryer chamber. Under these circumstances, temperatures of, for example, about 180° C. prevail, at least in a drying zone.

After the vehicle wheels have passed through the dryer chamber and the drying process in the drying oven has been completed, the vehicle wheels are conveyed out of the dryer chamber again, together with the workpiece-carrier. This means that the workpiece-carriers are conveyed together with the vehicle wheels as they pass through the dryer chamber.

On each occasion, therefore, it is also necessary to heat up the workpiece-carrier with the vehicle wheels, or workpieces in general, that are to be dried, which workpiece-carrier also cools down again with the workpieces after passing through the drying oven.

Depending upon the ratio between the weight of the workpiece-carrier and the weight of the workpieces on said workpiece-carrier, a considerable portion of energy is consumed for the purpose of heating up the workpiece-carrier in the course of each drying operation, a fact which significantly impairs the overall energy balance of the drying

device with respect to the workpieces to be dried, and thus increases the overall running costs of the installation.

It is therefore an object of the invention to provide a device and a method for drying workpieces of the kind initially mentioned, in which the energy balance is improved.

SUMMARY OF THE INVENTION

This object may be achieved, in the case of a device of the kind initially mentioned, through the fact that:

c) a transposing apparatus is present, by means of which:

ca) workpieces to be dried can be transferred to a workpiece-carrier which is located in the dryer chamber; and

cb) dried workpieces can be removed from a workpiece-carrier which is located in said dryer chamber;

so that

d) the workpiece-carriers can be conveyed in circulation through the dryer chamber without leaving said chamber.

What is achieved, according to the invention, as a result of these measures is that the workpiece-carriers are heated up only when the device starts up and then remain within an operating temperature range. Although, under these circumstances, the operating temperature of the workpiece-carriers can fluctuate within a range of several tens of degrees C., said workpiece-carriers nevertheless no longer have to be heated up from, say, ambient temperature to the operating temperature in the dryer chamber every time workpieces pass through, as is the case if the workpiece-carriers are conveyed with the workpieces as they pass through the device. As a result of this, a smaller portion, in total, of the overall energy which is needed for drying the workpieces is used for heating up the workpiece-carriers, as a result of which the energy balance of the installation is improved.

It is favourable if the dryer chamber comprises a pre-heating zone and a drying tunnel connected to the latter, whereby there prevails, in said pre-heating zone, a temperature which is lower than the temperature in the drying tunnel, and the pre-heating zone is accessible from outside via the at least one access. Since a heat loss occurs via the access, this can thus be kept lower than if the access were to lead directly to the drying tunnel having the higher temperature.

It is also of advantage, from a thermal technology point of view, if the drying tunnel is arranged at a different, in particular higher, vertical level than the pre-heating zone.

It is also advantageous if the drying tunnel is of two-storey construction and comprises a first tunnel conveyor and a second tunnel conveyor for workpiece-carriers, whereby the tunnel conveyors are arranged vertically one above the other and workpiece-carriers can be conveyed from the first tunnel conveyor to the second tunnel conveyor by means of a vertical transposing device. The path of the workpiece-carriers through the drying tunnel is thereby doubled, as a result of which efficient use is made of the available space, or the drying tunnel may optionally be built so as to be shorter than it would be without these measures.

In order to ensure effective circulation of the workpiece-carriers within the dryer chamber, it is favourable if a transfer apparatus having a vertically movable conveying carriage is arranged in the dryer chamber, by means of which apparatus workpiece-carriers can be conveyed out of the pre-heating zone and into the drying tunnel and vice versa, and the conveying carriage of which apparatus carries with it a first conveying support and a second conveying support which are arranged vertically one above the other, whereby it is possible to position the conveying carriage in such a

way that the first conveying support is capable of cooperating with the first tunnel conveyor and the second conveying support is capable of cooperating with the second tunnel conveyor. It is thus possible, in one conveying cycle with two steps in the movement of the conveying carriage, to introduce a workpiece-carrier with workpieces to be dried into the drying tunnel and to bring a workpiece-carrier with dried workpiece-carriers out of said drying tunnel. In this case, the feeding of workpieces to be dried into the drying tunnel and the discharging of dried workpieces from said drying tunnel take place at one and the same end of the tunnel.

An alternative circulatory design may advantageously be realised if the vertical conveyor serves as a delivery apparatus, by means of which dried workpieces can be conveyed out of the drying tunnel via one end of the latter, and a feed apparatus is present by means of which workpieces to be dried can be conveyed out of the pre-heating zone and into the drying tunnel via the other end of said tunnel.

With respect to the method, the abovementioned object may be achieved through the fact that:

a) the workpiece-carriers are conveyed in circulation through the dryer chamber without leaving said chamber; whereby:

b) workpieces to be dried are transferred to a workpiece-carrier which is located in the dryer chamber; and

c) dried workpieces are removed from a workpiece-carrier which is located in said dryer chamber.

The advantages of this and of the measures explained below correspond, mutatis mutandis, to the advantages which have been discussed in connection with the corresponding measures in the case of the device.

Consequently, it is favourable if the workpiece-carriers are conveyed through a pre-heating zone and a drying tunnel connected to the latter, whereby there is generated in said pre-heating zone a temperature which is lower than the temperature in the drying tunnel, and the pre-heating zone is accessible from outside via the at least one access.

Under these circumstances, the drying tunnel is preferably arranged at a different, in particular higher, vertical level than the pre-heating zone.

Furthermore, it is of advantage if the workpiece-carriers are guided through the drying tunnel in two storeys by means of a first tunnel conveyor and a second tunnel conveyor which are arranged vertically one above the other, whereby the workpiece-carriers are conveyed from the first tunnel conveyor to the second tunnel conveyor by means of a vertical transposing device.

Under these circumstances, the workpiece-carriers are preferably conveyed out of the pre-heating zone and into the drying tunnel and vice versa by means of a transfer apparatus which comprises a conveying carriage having a first conveying support and a second conveying support which are arranged vertically one above the other, whereby the conveying carriage may be positioned in such a way that the first conveying support is capable of cooperating with the first tunnel conveyor and the second conveying support is capable of cooperating with the second tunnel conveyor.

Alternatively, dried workpieces are conveyed, by means of the vertical conveyor, out of the drying tunnel via one end of said tunnel, and workpieces to be dried are conveyed, by means of a feed apparatus, out of the pre-heating zone and into the drying tunnel via the other end of said tunnel.

It is to be understood that the aspects and objects of the present invention described above may be combinable and that other advantages and aspects of the present invention will become apparent upon reading the following description of the drawings and detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the invention will be explained in greater detail below with the aid of the drawings, in which:

FIG. **1** shows a vertical section through a drying oven for vehicle wheels according to a first exemplary embodiment, along the sectional line I-I in FIGS. **2** and **3**, which is angled in each case;

FIG. **2** shows a further vertical section through the drying oven, along the angled sectional line II-II in FIG. **1**;

FIG. **3** shows a horizontal section through the drying oven, along the angled sectional line III-III in FIG. **1**;

FIG. **4** shows a further horizontal section through the drying oven, along the sectional line IV-IV in FIG. **1**; and

FIG. **5** shows a vertical section corresponding to FIG. **2** through a drying oven for vehicle wheels according to a second exemplary embodiment.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

While this invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail one or more embodiments with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiments illustrated.

In FIGS. **1** to **4**, a drying oven, in which workpieces are dried, is designated as a whole by **10** as a first exemplary embodiment of a device for drying objects. In the present exemplary embodiment, there are illustrated, as workpieces, vehicle wheels **12** for motor vehicles which are dried in the drying oven **10** after they have been provided, in one or more preceding treatment steps, with a surface coating, such as a paint for example.

The drying oven **10** comprises a thermally insulated dryer housing **14** which borders a dryer chamber **16**. Workpiece-carriers **20**, which are loaded with vehicle wheels **12**, are conveyed through the dryer chamber **16** with the aid of a conveying system which is identified, as a whole, by **18**. In the present exemplary embodiment, each workpiece-carrier **20** is capable of receiving three vehicle wheels **12**.

The dryer chamber **16** of the drying oven **10** comprises a pre-heating and discharging zone **22** at a first vertical level, and a drying tunnel **24** which is located at a second vertical level that is higher than the first vertical level of the pre-heating and discharging zone **22**. The pre-heating and discharging zone **22** and the drying tunnel **24** are connected to one another via a transfer chamber **26** belonging to the dryer chamber **16**. A temperature of about 70° C. to 80° C. prevails in the pre-heating and discharging zone **22**, whereas there is a temperature of about 180° C. in the drying tunnel **24**. The temperatures are generated and maintained with the aid of heating apparatuses, such as are known per se and which are intentionally not shown for the sake of clarity.

The drying tunnel **24** thus constitutes the actual dryer chamber in which the desired drying operation runs its course and in which the highest temperature prevails inside the dryer housing **14**.

Arranged parallel and side by side in the pre-heating and discharging zone **22** are a first chain conveyor **28** and a

second chain conveyor **30** which extend from a transverse conveying station **32**, which is located in front of an access **34** in the oven housing **14**, to the transfer chamber **26**. The dryer chamber **16** of the drying oven **10** is accessible from outside via the access **34**. Chain conveyors are known per se in many variants, for which reason a detailed description will be dispensed with.

The first chain conveyor **28** serves as a feed conveyor and conveys workpiece-carriers **20** from the transverse conveying station **32** to the transfer chamber **26** in a direction of transport T**1**, while the second chain conveyor **30** serves as a discharging conveyor and conveys workpiece-carriers **20** from a transfer station **36** to the transverse conveying station **32** in a direction of transport T**2**.

The directions of transport T**1** and T**2** are shown only in FIG. **4** and extend parallel but accordingly define mutually opposed directions of transport. The transverse conveying station **32** and the transfer station **36** are also capable of conveying the workpiece-carriers **20** in directions perpendicular to the directions of transport T**1** and T**2**, and comprise, for that purpose, raising/lowering platforms and conveying chains which cooperate in a manner known per se but which are intentionally not provided with a reference numeral.

Under these circumstances, the transverse conveying station **32** provides a first conveying position **32***a* and a second conveying position **32***b* for workpiece-carriers **20**. In the first conveying position **32***a*, a workpiece-carrier **20** is arranged both next to the discharging conveyor **30** and next to the access **34** in the oven housing **14**. In the second conveying position **32***b*, a workpiece-carrier **20** is arranged next to the feed conveyor **28** and next to the first conveying position **32***a*.

Arranged vertically one above the other in the drying tunnel **24** of the drying oven **10** are a first, upper and a second, lower tunnel conveyor, **38** and **40** respectively, for the workpiece-carriers **20**, as a result of which the drying tunnel **24** comprises two storeys. These two tunnel conveyors **38**, **40** are, once again, constructed as chain conveyors in a manner known per se and, in the present exemplary embodiment, extend, and effect conveying, in directions T**3** and T**4** which extend at right angles to the directions of transport T**1** and T**2** of the feed conveyor **28** and discharging conveyor **30**, respectively, in the pre-heating and discharging zone **22**, and extend in opposite directions to one another. The directions of transport T**3** and T**4** are shown only in FIG. **2**. Under these circumstances, the workpiece-carriers **20** are conveyed transversely to their longitudinal direction.

The two tunnel conveyors **38**, **40** extend between the transfer chamber **26** and a vertical conveyor in the form of a vertical transposing device **42** at the opposite end of the drying tunnel **24**. With the aid of the vertical transposing device **42**, workpiece-carriers **20** can be transposed from the upper tunnel conveyor **38** to the lower tunnel conveyor **40**. For this purpose, the vertical transposing device **42** comprises a transposing carriage **46** which is capable of moving vertically on a vertical rail **44** and has a transposing support **48** and which is selectively oriented, in an upper receiving position of the transposing carriage **46**, in a manner which is in alignment, for conveying purposes, with the upper tunnel conveyor **38** or, in a lower delivery position of said transposing carriage **46**, in a manner which is in alignment, for conveying purposes, with the lower tunnel conveyor **40**. In the present case, an "orientation or arrangement of two conveying components which is in alignment for conveying purposes" should be understood to mean that a workpiece-carrier **20** can then be transferred from one conveying component to another conveying component.

The transposing support **48** is capable of both receiving workpieces **12** from the upper tunnel conveyor **38** from the latter's direction of transport T**3**, and of delivering them to the lower tunnel conveyor **40** in the latter's direction of transport T**4**.

Arranged in the transfer chamber **26** of the drying oven **10** is a transfer apparatus **50** by means of which workpiece-carriers **20** can be lifted out of the pre-heating and dischargінge zone **22** and into the drying tunnel **24**, or lowered out of said drying tunnel **24** and into the pre-heating and dischargінge zone **22**.

The transfer apparatus **50** comprises a two-storey conveying carriage **52** which comprises an upper conveying support **54** and a lower conveying support **56** which is arranged directly below the latter and which corresponds, structurally, to the transposing support **48** belonging to the vertical transposing device **42** in the drying tunnel **24**. The upper conveying support **54** is capable of delivering a workpiece-carrier **20** in the direction of the direction of transport T**3** of the upper tunnel conveyor **38**, while the lower conveying support **56** of the conveying carriage **52** is capable of receiving a workpiece-carrier **20** from the direction of the direction of transport T**4** of the lower tunnel conveyor **40**.

The conveying carriage **52** can be moved vertically along a guide structure **58**, in which case three working positions are of interest.

In a first, uppermost working position, the upper conveying support **54** of the conveying carriage **52** is in alignment, for conveying purposes, with the upper tunnel conveyor **38**, while the lower conveying support **56** of the conveying carriage **52** is in alignment, for conveying purposes, with the lower tunnel conveyor **40** in the drying tunnel **24**. This working position of the conveying carriage **52** can be seen in FIG. **2**.

In a second, central working position of the conveying carriage **52**, the lower conveying support **56** of said carriage is in alignment, for conveying purposes, with the feed conveyor **28** in the pre-heating and discharging zone **22** and also with the transfer station **52** in the transfer chamber **26**.

In a third, lowermost working position of the conveying carriage **52**, the lower conveying support **56** of said carriage is in alignment, for conveying purposes, both with the feed conveyor **28** in the pre-heating and discharging zone **22** and also with the transfer station **36** in the transfer chamber **26**.

Arranged in front of the access **34** in the dryer housing **14** to the dryer chamber **16** is a transposing apparatus **60** which, in the present exemplary embodiment, is constructed in the form of a multi-axis handling robot **62**. Said handling robot **62** carries with it a gripping unit **64** which is represented only diagrammatically, which is adapted to the arrangement of the vehicle wheels **12** on the workpiece-carriers **20**, and by means of which three vehicle wheels **12** can be received.

The handling robot **62** may, on the one hand, reach the conveying position **32***a* of the transverse conveyor **32** in the pre-heating and discharging zone **22** through the access **34**. On the other hand, there is arranged, within the working range of the handling robot **62**, a workpiece-conveyor **66** in the form of a further chain conveyor, with the aid of which vehicle wheels **12** to be dried are conveyed on workpiece-carriers **68** to the drying oven **10**, and dried vehicle wheels **12** are conveyed, on the said workpiece-carriers **68**, away from the drying oven **10**.

The drying oven **10** described above is now operated as follows:

The arrangement, which is shown in FIGS. **1** to **4**, of the individual conveying components and workpiece-carriers **20** with vehicle wheels **12** will be assumed as the starting situation. Accordingly, an unloaded workpiece-carrier **20** is located in the first conveying position **32***a* of the transverse conveying station **32**, and a workpiece-carrier **20** loaded with vehicle wheels **12** is located in the second conveying position **32***b* of said station.

Located on the feed conveyor **28** are workpiece-carriers **20** with vehicle wheels **12** which are to be dried, while the discharging conveyor **30** conveys, on workpiece-carriers **20**, vehicle wheels **12** which have already been dried.

Located on the tunnel conveyors **38** and **40** are workpiece-carriers **20** with vehicle wheels **12** which are just being dried.

The transposing support **48** of the transposing carriage **46** belonging to the vertical transposing device **42** has received a loaded workpiece-carrier **20** from the upper tunnel conveyor **38**, whereby the transposing carriage **46** is still located in its upper receiving position.

The conveying carriage **52** of the transfer apparatus **50** assumes its uppermost working position, whereby its upper conveying support **54** carries a loaded workpiece-carrier **20** and its lower conveying support **56** is empty. The transfer station **36** is also empty.

A workpiece-carrier **68** with vehicle wheels **12** to be dried is positioned on the workpiece-conveyor **66** in front of the handling robot **62**.

With the aid of its gripping unit **64**, said handling robot **62** now receives these vehicle wheels **12** to be dried from the workpiece-carrier **68** and brings them into the pre-heating and discharging zone **22** through the access **34** in the dryer housing **14**. There, it deposits the vehicle wheels **12** on the workpiece-carrier **20** in the first conveying position **32***a* of the transverse conveying station **32**. The workpiece-carrier **68**, which is now empty, on the workpiece-conveyor **66** remains there in its position.

The transposing carriage **46** of the vertical transposing device **42** in the drying tunnel **24** is now, first of all, moved vertically downwards into its lower delivery position.

The loaded workpiece-carriers **20** are then conveyed, on the lower tunnel conveyor **40**, in the latter's direction of conveyance T**4**, whereby the loaded workpiece-carrier **20** adjacent to the transfer chamber **26** is transferred to the lower conveying support **56** of the conveying carriage **52** of the transfer apparatus **50**. At the same time, the loaded workpiece-carrier **20** on the transposing carriage **46** of the vertical transposing device **42** moves up onto the lower tunnel conveyor **40**. The transposing carriage **46** is then moved vertically upwards into its upper receiving position.

The vehicle wheels **12** on the workpiece-carrier **20**, which is now arranged on the lower conveying support **56** of the conveying carriage **52**, have passed through the drying tunnel **24**, as a result of which the desired drying process has been completed.

The workpiece-carriers **20** on the upper tunnel conveyor **38** are now conveyed, in the latter's direction of transport T**3**, in the direction of the vertical transposing device **42**, whereby a workpiece-carrier **20** moves up onto the transposing support **48** of said device. At the same time, the workpiece-carrier **20** on the upper conveying support **54** of the conveying carriage **52** of the transfer apparatus **50** is moved from the latter up onto the upper tunnel conveyor **38**.

After that, the conveying carriage **52** of the transfer apparatus **50** is moved into its central working position, and the workpiece-carrier **20** on the lower conveying support **56** is transferred, in the horizontal direction, to the transfer station **36**.

The conveying carriage **52** of the transfer apparatus **50** is now moved into its lowermost working position, and the workpiece-carriers **20** on the feed conveyor **28** are moved, in the latter's direction of transport T**1**, in the direction of the conveying carriage **52**, whereby a loaded workpiece-carrier **20** moves up onto the upper conveying support **54** of said carriage. The conveying carriage **52** is then moved into its uppermost working position again.

At the same time, the workpiece-carrier **20** is transferred from the second conveying position **32***b* of the transverse conveying station **32** to the feed conveyor **28**, so that the second conveying position **32***b* is now free.

The transverse conveying station **32** now brings the workpiece-carrier **20**, which has been freshly loaded from outside with vehicle wheels **12** which are still to be dried, from the first conveying position **32***a* into the second conveying position **32***b*. The workpiece-carriers **20** on the discharging conveyor **30** are then moved in the direction of the transverse conveying station **32** and the foremost workpiece-carrier **20** in the direction of transport T**2** is transferred to said transverse conveying station **32**, where it assumes the first conveying position **32***a* in front of the access **34** in the dryer housing **14**. In the process, the workpiece-carrier **20** on the transfer station **36** is given a subsequent push onto the discharging conveyor **28**.

The handling robot **62** now receives the dried vehicle wheels **12** of the workpiece-carrier **20** in the first conveying position **32***a* of the transverse conveying station **32**, whereby the workpiece-carrier **20** remains in the pre-heating and discharging zone **22**. The handling robot **62** transfers these dried vehicle wheels **12** to the empty workpiece-carrier **68** which is waiting on the workpiece-conveyor **66**. The latter conveys the workpiece-carrier **68**, which is now loaded with the dried vehicle wheels **12**, onwards, for example to a cooling zone for said wheels. In the process, a new workpiece-carrier **68**, which, however, carries with it vehicle wheels **12** to be dried, moves up instead in front of the handling robot **62**, and the cycle explained above is repeated.

By means of the transposing apparatus **60**, it is thus possible to both transfer vehicle wheels **12** which are to be dried to a workpiece-carrier **20** which is located in the dryer chamber **16**, and to remove dried vehicle wheels **12** from a workpiece-carrier **20** which is located in said dryer chamber **16**. As a result of this, it is possible for the workpiece-carriers **20** to be conveyed in circulation through the dryer chamber **16** without leaving said chamber.

As a result, the workpiece-carriers **20** only cool down slightly before they are fed into the drying tunnel **24** again, and a lower input of heat into the workpiece-carriers **20** takes place than in the case in which workpiece-carriers are not guided in circulation, but are guided through, a drying oven. In the case of the temperatures of 70° C. to 80° C., which are indicated above by way of an example, in the pre-heating and discharging zone **22**, and of about 180° C. in the drying tunnel **24**, the workpiece-carriers **20** only cool down to about 150° C., for example. In a modification of the drying oven **10** explained above, it is also possible for there to be a number of accesses and not just the single access **34**. For example, there may be a second access in front of the access **34** in the direction of transport T**2**, via which a second transposing apparatus is capable of reaching the discharging conveyor **30**. It is then possible for vehicle wheels **12** which have already been dried to be removed, by means of the

second transposing apparatus via the second access, from a workpiece-carrier **20** on the discharging conveyor **30**, and for vehicle wheels **12** which are to be dried to be brought, in a synchronized manner via the access **34**, onto a workpiece-carrier **20** which has already been emptied. As a result of this, it is possible to increase the number of cycles and thereby the throughput of the drying oven **10**.

In another modification, which is intentionally not shown, the access **34** is constructed as a lock, by means of which the discharge of heat via the opening to the pre-heating and discharging zone **22** is reduced. A lock of this kind may be constructed, for example, as a simple roller gate. If a number of accesses are present, these may accordingly all be in the form of a lock of this kind.

A drying oven **70** having a different conveying design, compared to the drying oven **10**, is shown in FIG. **5** as a second exemplary embodiment. In the drying oven **70**, components which correspond to those of the drying oven **10** according to FIGS. **1** to **4** bear the same reference numerals. In this connection, what has been stated above regarding the drying oven **10** also applies in a corresponding manner, mutatis mutandis, to the drying oven **70**, provided nothing to the contrary is explained below.

In the case of the drying oven **70**, the joint pre-heating and discharging zone **22** of the dryer chamber **16** is broken up and divided spatially into a separate pre-heating zone **72** and a separate discharging zone **74** belonging to the dryer chamber **16**.

Instead of the transfer chamber **26**, there is now provided a feed chamber **76** next to one end of the drying tunnel **24**, while a delivery chamber **78** is arranged next to the opposite end of said drying tunnel **24**. The pre-warming zone **72** is located vertically below the feed chamber **76**, while the discharging zone **74** lies vertically below the delivery chamber **78**.

Instead of the transfer apparatus **50** having the conveying carriage **52** and the two conveying supports **54** and **56**, there is now a feed apparatus **80** having a single-storey feed carriage **82** which carries with it only a single carriage support **84**. Said carriage support **84** is capable of both delivering a workpiece-carrier **20** in the direction of the direction of transport T**3** of the upper tunnel conveyor **38**, and of receiving a workpiece-carrier **20** from the direction of the direction of transport T**4** of the lower tunnel conveyor **40**. The feed carriage **82** can be moved vertically along a guide structure **86** which extends upwards from the pre-heating zone **72** into the feed chamber **76** and connects them together for conveying purposes. In this connection, the following three working positions of the feed carriage **82** are now of interest:

In a first, uppermost working position, the carriage support **84** of the feed carriage **82** is in alignment, for conveying purposes, with the upper tunnel conveyor **38**, as is shown in FIG. **5**.

In a second, central working position of the feed carriage **82**, the latter's carriage support **84** is in alignment, for conveying purposes, with the lower tunnel conveyor **40** in the drying tunnel **24**.

In a third, lowermost working position of the feed carriage **82**, the latter is located in the pre-heating zone **72** in front of a feed access **88** belonging to the dryer housing **14**, which access leads to said pre-heating zone **72** and may be closed, for example, by a roller gate.

Instead of the vertical transposing device **42** of the drying oven **10**, with the aid of which workpiece-carriers **20** can be transposed from the upper tunnel conveyor **38** to the lower tunnel conveyor **40**, there is provided, in the case of the drying oven **70**, a delivery apparatus **90** which likewise constitutes a vertical conveyor and which comprises a delivery carriage **92** having likewise only a single carriage support **94**. The carriage support **94** of the delivery apparatus **90** is capable of both receiving a workpiece-carrier **20** from the direction of the direction of transport T**3** of the upper tunnel conveyor **38** and of delivering a workpiece-carrier **20** in the direction of the direction of transport T**4** of the lower tunnel conveyor **40**.

The delivery carriage **92** can be moved vertically along a guide structure **96** which extends upwards from the discharging zone **74** into the delivery chamber **78** and connects them to one another for conveying purposes. In this connection, attention is to be drawn to the following three working positions of the delivery carriage **92** in the case of the delivery apparatus **90**:

In a first, uppermost working position, the carriage support **94** of the delivery carriage **92** is in alignment, for conveying purposes, with the upper tunnel conveyor **38**.

In a second, central working position of the delivery carriage **92**, the latter's delivery support **94** is in alignment, for conveying purposes, with the lower tunnel conveyor **40** in the drying tunnel **24**.

In a third, lowermost working position of the delivery carriage **92**, the latter is located in the discharging zone **74** in front of a delivery access **98** of the dryer housing **14**, which access leads to said discharging zone **74** and, once again, can be closed by means of a roller gate.

Instead of the workpiece-conveyor **66**, there are present, in the case of the drying oven **70**, a feed conveyor **100** and a delivery conveyor **102**, which are each constructed as chain conveyors. The feed conveyor **100** conveys vehicle wheels **12** which are to be dried towards the drying oven **70** on workpiece-carriers **104**, and the delivery conveyor **102** conveys dried vehicle wheels **12** away from said drying oven **70** on separately guided workpiece-carriers **106**.

In the case of the drying oven **70**, the transposing apparatus **60** comprises a feed robot **108**, which is arranged in front of the feed access **88**, and a removal robot **110**, which is arranged in front of the delivery access **98**, the two robots **108** and **110** corresponding structurally to the handling robot **62** of the drying oven **10**.

The feed robot **108** is capable, on the one hand, of reaching the carriage support **84** of the feed carriage **82** of the feed apparatus **80** through the feed access **88**. On the other hand, the feed conveyor **100** is located within the working range of the feed robot **108**. Similarly, the removal robot **110** is capable of reaching, on the one hand, the carriage support **94** of the delivery carriage **92** of the delivery apparatus **80** through the delivery access **98** and, on the other hand, the delivery conveyor **102**.

The drying oven **70** described above is now operated as follows:

The arrangement, which is shown in FIG. **5**, of the individual conveying components and also workpiece-carriers **20**, with or without vehicle wheels **12**, will be assumed as the starting situation.

Accordingly, there are located on the upper tunnel conveyor **38** workpiece carriers **20** with vehicle wheels **12** which are just being dried, whereas only unloaded workpiece-carriers **20** are transported on the lower tunnel conveyor **20**.

In its uppermost working position, the feed carriage **82** of the feed apparatus **80** is located next to the upper tunnel conveyor **38** and is empty, that is to say there is likewise no workpiece-carrier on the carriage support **84** of said conveyor. On the feed conveyor **100**, outside the dryer housing

14, a loaded workpiece-carrier **104** is positioned in front of the feed robot **108**, the gripping unit **64** of which is, in turn, empty.

The delivery carriage **92** of the delivery apparatus **90**, on the other hand, has assumed its lowermost working position next to the delivery access **98**, and carries a workpiece-carrier **20**, whereby the removal robot **110** has received vehicle wheels **12**, which have just been dried, from said workpiece-carrier **20**. Positioned on the delivery conveyor **102**, next to said removal robot **110**, is an empty workpiece-carrier **106**.

The removal robot **110** first of all guides the dried vehicle wheels **12** through the delivery access point **98** and out of the discharging zone **74**, and thereby out of the dryer chamber **16**, and deposits them on the workpiece-carrier **106**. The two carriages **82** and **92** of the feed apparatus **80** and the delivery apparatus **90** then move into their central working position, next to the lower tunnel conveyor **40** in the drying tunnel **24** in each case.

The workpiece-carriers **20** on the lower tunnel conveyor **40** are now conveyed in the latter's direction of transport T**4**, whereby an unloaded workpiece-carrier **20** moves up onto the carriage support **84** of the feed carriage **82**. At the same time, the unloaded workpiece-carrier **20** on the carriage support **94** of the delivery carriage **92** is moved up onto the lower tunnel conveyor **40**, so that said delivery carriage **92** is empty.

The feed carriage **82** then moves, with the unloaded workpiece-carrier **20**, into its lowermost working position in front of the feed access **88**, where it is loaded, by means of the feed robot **108**, with vehicle wheels **12** which are to be dried.

Both the feed carriage **82**, which is now loaded, and the empty delivery carriage **92** then move into their uppermost working position, in each case, next to the upper tunnel conveyor **38**. The loaded workpiece-carriers **20** on the upper tunnel conveyor **38** are now conveyed in the latter's direction of transport T**3**, whereby a loaded workpiece-carrier **20** moves up onto the carriage support **94** of the delivery carriage **92**, and the loaded workpiece-carrier **20** moves up from the carriage support **84** of the feed carriage **82** onto the upper tunnel conveyor **38**, so that the feed carriage **82** is now empty, as is shown in FIG. **5**.

After this, the delivery carriage **92** moves into its lowermost working position in front of the delivery access **98** in the dryer housing **14**, where the vehicle wheels **12** are received by the removal robot **110** and transferred to the delivery conveyor **102**.

The cycle is then repeated.

In the case of the drying oven **70** too, it is possible, by means of the transposing apparatus **60**, both to transfer vehicle wheels **12** which are to be dried to a workpiece-carrier **20** which is located in the dryer chamber **16**, and to remove dried vehicle wheels **12** from a workpiece-carrier **20** which is located in said dryer chamber. As a result of this, it is possible for the workpiece-carriers **20** to be conveyed in circulation through the dryer chamber **16** without leaving said chamber.

It is to be understood that additional embodiments of the present invention described herein may be contemplated by one of ordinary skill in the art and that the scope of the present invention is not limited to the embodiments disclosed. While specific embodiments of the present invention have been illustrated and described, numerous modifications come to mind without significantly departing from the spirit of the invention, and the scope of protection is only limited by the scope of the accompanying claims.

The invention claimed is:

1. A device for drying workpieces comprising:

a) a dryer housing which borders a dryer chamber and has at least one access to the dryer chamber, wherein the dryer chamber comprises

aa) a pre-heating and discharge zone comprising a first conveyor and a second conveyor,

ab) a drying tunnel arranged vertically above the pre-heating zone, the drying tunnel being of a two-story configuration and comprising a first drying tunnel conveyor arranged vertically above a second drying tunnel conveyor,

ac) a transfer apparatus for vertically moving workpiece-carriers loaded with workpieces from

aca) the first conveyor to the first drying tunnel conveyor, and

acb) the second drying tunnel conveyor to the second conveyor, and

ad) a vertical conveyor for vertically moving workpiece-carriers loaded with workpieces from the first drying tunnel conveyor to the second drying tunnel conveyor;

b) a transposing apparatus which

ba) transfers workpieces to be dried to a workpiece-carrier which is located in the dryer chamber; and

bb) removes dried workpieces from a workpiece-carrier which is located in said dryer chamber; so that

c) the workpiece-carriers can be conveyed in circulation through the dryer chamber without leaving said chamber.

2. The device according to claim **1**, wherein a temperature in the pre-heating zone is lower than a temperature in the drying tunnel, and said pre-heating zone is accessible from outside via the at least one access.

3. The device according to claim **1**, wherein the transfer apparatus has a vertically movable conveying carriage, having a first conveying support and a second conveying support which are arranged vertically one above the other, whereby it is possible to position the conveying carriage in such a way that the first conveying support is capable of cooperating with the first tunnel conveyor and the second conveying support is capable of cooperating with the second tunnel conveyor.

4. A method for drying workpieces, the method comprising the steps of:

a) conveying workpiece-carriers through a pre-heating zone on a first conveyor,

b) moving the workpiece-carriers vertically from the first conveyor to a first drying tunnel conveyor in a drying tunnel;

c) conveying the workpiece-carriers through the first drying tunnel conveyor;

d) moving the workpiece-carriers vertically from the first drying tunnel conveyor to a second drying tunnel conveyor arranged beneath the first drying tunnel conveyor;

e) conveying the workpiece-carriers through the second drying tunnel conveyor;

f) moving the workpiece-carriers from the second drying tunnel conveyor to a second conveyor in a discharge zone, the second conveyor being positioned adjacent the first conveyor;

whereby:

g) workpieces to be dried are transferred to a workpiece-carrier through an access which is located in a dryer chamber which comprises the pre-heating chamber and the drying tunnel; and

h) dried workpieces are removed from a workpiece-carrier through the access which is located in said dryer chamber without requiring removal of the workpiece-carriers from the dryer chamber.

5. The method according to claim **4**, wherein a temperature in a pre-heating zone is lower than a temperature in a drying tunnel, and the pre-heating zone is accessible from outside via at least one access.

6. The method according to claim **5**, wherein the drying tunnel is arranged at a different vertical level than the pre-heating zone.

7. The method according to claim **5**, wherein the workpiece-carriers are conveyed from the first drying tunnel conveyor to the second drying tunnel conveyor by a vertical conveyor.

8. The method according to claim **7**, wherein the workpiece-carriers are conveyed out of the pre-heating zone and into the drying tunnel and vice versa by a transfer apparatus which comprises a conveying carriage having a first conveying support and a second conveying support which are arranged vertically one above the other, whereby the conveying carriage may be positioned in such a way that the first conveying support is capable of cooperating with the first tunnel conveyor and the second conveying support is capable of cooperating with the second tunnel conveyor.

9. A device for drying workpieces comprising:

a) a dryer housing which borders a dryer chamber and has an access to the dryer chamber;

b) a conveying system which conveys workpiece-carriers loaded with workpieces through the dryer chamber;

c) a transposing apparatus;

d) a transverse conveying apparatus arranged adjacent the access, the transverse conveying apparatus providing a first conveying position and a second conveying position for workpiece-carriers, wherein the transposing apparatus removes dried workpieces from a workpiece-carrier through the access when the workpiece carrier is in the first conveying position, and the transposing apparatus transfers workpieces to be dried to the workpiece-carrier through the access when the workpiece carrier is in the second conveying position, so that

e) the workpiece-carriers can be conveyed in circulation through the dryer chamber without leaving the dryer chamber.

10. The device according to claim **9**, wherein the dryer chamber comprises a pre-heating zone and a drying tunnel connected to the latter, whereby there prevails, in said pre-heating zone, a temperature which is lower than a temperature in the drying tunnel, and said pre-heating zone is accessible from outside via the access.

11. The device according to claim **10**, wherein the drying tunnel is arranged at a different vertical level than the pre-heating zone.

12. The device according to claim **10**, wherein the drying tunnel is of two-story construction and comprises a first tunnel conveyor and a second tunnel conveyor for workpiece-carriers, whereby the tunnel conveyors are arranged vertically one above the other and workpiece-carriers can be conveyed from the first tunnel conveyor to the second tunnel conveyor by means of a vertical conveyor.

13. The device according to claim **12**, wherein a transfer apparatus having a vertically movable conveying carriage is arranged in the dryer which conveys apparatus workpiece-carriers out of the pre-heating zone and into the drying tunnel and vice versa, and the conveying carriage of which apparatus carries with it a first conveying support and a second conveying support which are arranged vertically one above the other, whereby it is possible to position the conveying carriage in such a way that the first conveying support is capable of cooperating with the first tunnel conveyor and the second conveying support is capable of cooperating with the second tunnel conveyor.

14. The device of claim **13**, wherein the transfer apparatus is located adjacent the access.

15. The device according to claim **10**, wherein the pre-heating zone is arranged adjacent a discharge zone, the pre-heating zone comprising a first conveyor and the discharge zone comprising a second conveyor.

16. The device according to claim **15**, wherein the workpiece carrier is arranged adjacent the second conveyor when in the first conveying position and the workpiece carrier is arranged adjacent the first conveyor when in the second conveying position.

17. The device according to claim **16** wherein the transverse conveying station is arranged transverse to a direction of travel of the first conveyor and transverse to a direction of travel of the second conveyor.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 10,184,720 B2
APPLICATION NO. : 14/116802
DATED : January 22, 2019
INVENTOR(S) : Binder et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Specification

At Column 6, Line 42, replace the reference number "52" with the reference number -36-.

At Column 6, Line 44, replace the words "lower conveying support 56" with the words -upper conveying support 54-.

Signed and Sealed this
Twenty-eighth Day of May, 2019

Andrei Iancu
Director of the United States Patent and Trademark Office